Complexity Sciences

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Theoretical and Empirical Approaches to Social Action

Edited by

Manuel Lisboa and Dalila Cerejo

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CHAPTER I

INTRODUCTION: SOCIOCYBERNETICS FRAMEWORK

CHAIME MARCUELLO-SERVÓS

Sociocybernetics is a strange word. There are few people who understand its meaning, history and scope. It is a neologism created in the mid-80s of the past century. The editor of a collection of papers, Felix Geyer, coined it in cooperation with his publisher. In 1998, during the World Congress of Sociology at Montreal, the executive committee of the International Sociological Association (ISA) established the Research Committee 51 (RC51) on Sociocybernetics as the last step of a long process initiated in the '80s with the Ad Hoc Group by Francisco Parra-Luna.

Considering this institutional process, Sociocybernetics could be understood as the target and object of the RC51 and the people involved in its activities. Sociocybernetics is the result of the "sociocyberneticians", but this answer drives us into a circular definition, which requires a second-order observation. Moreover, in a first attempt, if we are inside the ISA logics, Sociocybernetics could be understood as a field in Social Sciences, like Family Research (RC06), Sociology of Education (RC04), Social Indicators (RC55) or any other of the current fifty-six research committees on the ISA. However, as Bernd Hornung has proposed several times in different conversations and conferences: "Sociocybernetics is not a particular field; it should be defined as a paradigm" because it is a way of thinking and doing social sciences.

In practice, the RC51's own definition can help to comprehend this notion.

> Sociocybernetics can be defined as "Systems Science in Sociology and Other Social Sciences" – systems science, because sociocybernetics is not limited to theory but includes application, empirical research, methodology, axiology (i.e., ethics and value research), and epistemology. In general use, "systems theory" and "cybernetics" are frequently

> interchangeable or appear in combination. Hence, they can be considered as synonyms, although the two terms come from different traditions and are not used uniformly in different languages and national traditions. Sociocybernetics includes both what are called first order cybernetics and second order cybernetics. Cybernetics, according to Wiener´s original definition, is the science of "control and communication in the animal and the machine". Heinz von Foerster went on to distinguish a first order cybernetics, "the study of observed systems", and a second order cybernetics, "the study of observing systems". Second order cybernetics is explicitly based on a constructivist epistemology and is concerned with issues of self-reference, paying particular attention to the observer-dependence of knowledge, including scientific theories. In the interdisciplinary and holistic spirit of systems science, although sociology is clearly at the centre of interest of sociocybernetics, the other social sciences, such as psychology, anthropology, political science, economics, are addressed as well, with emphases depending on the particular research question to be dealt with.[1]

This long quote must be reread and reconsidered. Sociocyberneticians want to recognize the link with "systems science". This first is one of the three main roots. The resonance with Bertalanffy's general system theory,[2] Kenneth E. Boulding and many others such as Parsons and Luhmann is clear. The second is "cybernetics". This was another new term. It was the title of Norbert Wiener's book *Cybernetics: Or Control and Communication in the Animal and the Machine* published in 1948. The third root is "second order cybernetics", as von Foerster (2003) proposed. At this point, it is useful to paraphrase his words: "Sociocybernetics' description is nothing but Sociocybernetics".[3] These three pillars underpin Sociocybernetics – as in the construction of the knowledge paradigm of Rolando García (2000) inspired by the genetic epistemology of Jean Piaget – and as in the work of social scientists practising "the emerging sciences of complexity".

According to von Foerster, when you learn and become interested in cybernetics, "definitions are not good".[4] And he continued by saying, "Don't ask, what is 'cybernetics'? Ask, when is cybernetics?" Maybe,

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[1] See the website of the RC51 https://sociocybernetics.wordpress.com/about/what-is-sociocybernetics/ or http://sociocybernetics.unizar.es/whatis.html

[2] 1968, *General System Theory: Foundations, Development, Applications*, New York: George Braziller.

[3] The original words are: "We can use the insight that computing a description is nothing but computing. This way we reach a final paraphrasing of the forever renewed process of knowledge acquisition" (von Foerster, 2003, 232).

[4] Listen to the voice of Heinz von Foerster directly in 2'40" at: https://www.youtube.com/watch?v=GWcyHbmsXS0

that's the same in the case of Sociocybernetics: a way of looking at things while conscious of the circularity of communications that produces effects in social systems and in individuals. This is the framework for this book. It is a collection of papers selected from the communications of the 11th International Conference of Sociocybernetics celebrated at the Algarve University in Faro (Portugal).

Complexity and Social Action: Interaction and Multiple Systems was the theme for the conference and is the focus for this book. Then, as now, recent events in different contexts of the world force us to think better and create *new theory settings, new approaches and new insights into the current social dynamics that many consider to be on the verge of rupture.* If, at the height of the recent global crisis, financial issues, social uprisings, forced government collapses and increasing inequalities within several spheres of the social world were *some of the events that necessarily put collective and individual social action into new perspectives,* recent events like the war in Syria, the refugee crisis, Brexit and the election of Donald Trump are similarly challenging.

Sociocyberneticians propose that it is

> no longer possible to think of social phenomena in a disconnected way, since their foundations and limits are not clear. The understanding of social action and interaction, as cause and consequence of social phenomenon, depends on the capacity to consider and analyse all possibilities in action systems, their diversity and relations integrating micro, macro and meso perspectives. It is therefore, imperative for the sociocybernetic approach to address such a challenge.

These pages address that challenge. The book is divided into ten chapters, including this introduction, that show the interaction between multiple systems and topics, using sociocybernetic ways of thinking and transdisciplinary approaches.

José A. Amozurrutia presents "A sociocybernetic approach to enhancing research reflexivity: An epistemology model for social analysis" and proposes an operationalization of Jean Piaget's genetic epistemology for the analysis of research activity in social projects. He considers that epistemology is grounded on the construction of general knowledge, and applies it to the cognitive processes of social agents in their research activity. Its main use takes the form of a construction and development knowledge field model, oriented to finding possible paths and equilibration trajectories in system development processes.

Margarita Maass offers a "Proposal for the development of a thinking culture as a large system formed by multiple sub-systems". Focusing on

Mexico as a multicultural and diverse country, she is concerned primarily with a proposal for the development of a thinking culture as a large system formed by multiple sub-systems. She describes how sociocybernetics helps us understand and explain culture as an ethno-ecosystem. Moreover, she explains how sociocybernetics allows us to construct a methodology for facilitating an emerging community of local knowledge system.

Leandro Aramburu and Chaime Marcuello-Servós put forward "Digital generation, emotions and social movements: A conceptual framework". The authors explore, first, information and communication technologies and their contextual consequences; second, some conceptual milestones for understanding how the digital generations are building a social architecture where emotions and meanings are supported by a different way of doing and thinking; and third, a theoretical framework is proposed that conceptualizes and describes the effects of the "internetization" and "digitalization" of our lives and, especially, its effects in the emergence of social movements.

Bernard Scott presents "Reflections on the sociocybernetics of social networks". He uses concepts from sociocybernetics to explore how the term "social network" is used, asks what is social about a social network and argues that what is usually intended are forms of reciprocity between social actors and the expectation structures that underpin them. In his paper, Scott goes on to consider the various forms that social networks may take and discusses related topics, such as social network, social system, social media, social empowerment, and the form of the emerging global conversation.

Bernd Hornung's contribution is focused on "Man, motivation and emotion at work in organizations – Behaviour, action and emotion in a multi-system environment", using the example of a university hospital as a particularly complex system. The chapter outlines a number of possible problems resulting from such a multi-system situation at the level of the individual working in such a context. He uses research on emotions in organizations, recent trends in the development of health problems in the working population and, last but not least, the phenomenon of burn-out. The author concludes with a number of suggestions about how work satisfaction might be promoted and developed by running a business organization in a sociocybernetically informed way.

Ana Ferreira addresses "Reasoning on emotions: Drawing an integrative approach". She discusses Barbalet's theoretical perspective on emotions and António Damásio's work to show that socially imprinted non-conscious physiological variables are available to actors facing uncertainty, allowing unconscious decision-making when rational and conscious analysis is impossible. As she says, by “not precluding knowledge specialization, but rather, crossing socially-constructed disciplinary boundaries, we aim to gather a deeper understanding of social action”.

Manuel Lisboa’s theme is “Toward an intersystemic analysis of gender-based violence”. He proposes an analysis of gender-based violence against women supported by systems theory, the result of questions raised over the last 20 years in the course of several studies of violence against women. He proposes a holistic and systemic analysis of the phenomenon. According to this analysis, we must consider three dimensions: (i) the study of the relationship between structural traits, both social and cultural, and the individual actors’ actions; (ii) the relationship between the rational control of these actions and the emotional factors also present; and (iii) how the social actors directly involved in acts of violence act according to their own syntheses of all existing constraints. Lisboa considers the first two aspects.

Dalila Cerejo’s chapter is concerned with “Emotional expression indicators as a systemic approach to exploring social (inter)action: The case of Portuguese intimate partner violence victims”. The aim of the chapter is to identify the reasons why victims stay with the abuser, sometimes during long periods of victimization. The author uses emotional expression indicators (EEI) detection in intimate partner violence (IPV) contexts. As she says, IPV is a complex social phenomenon and a multidisciplinary and systemic approach is considered crucial to unveiling more about the factors that create it.

José A. Amozurrutia, Santiago Boira, María F. del Castillo and Chaime Marcuello-Servós describe “Gender violence in Spain: A qualitative and systemic approach”. The chapter offers a qualitative and systemic approach to gender violence and its recent evolution in Spain. Spanish society has experienced a deep transformation in the last three decades. The authors analyse the context and focus on its consequences for sex roles and gender violence. They studied these phenomena heuristically, considering the discourses of aggressors, victims and professionals directly involved in the problem. The authors find that fear, amongst other things, is the main feature of the symbolic universe around gender violence, in the period after the 1/2004 Integral Protection Measures against Gender Violence Act.

This variety of chapters and authors provides a sample of the activities of sociocyberneticians. We hope you enjoy reading the book and encourage you to reflect on how the chapters interact. Sociocybernetics can be seen as a self-reproducing and evolving system in which people, ideas and findings interact in an autopoietic way.

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CHAPTER II

A SOCIOCYBERNETIC APPROACH TO ENHANCING RESEARCH REFLEXIVITY: AN EPISTEMOLOGY MODEL FOR SOCIAL ANALYSIS

JOSÉ A. AMOZURRUTIA

In this chapter, I propose an operationalization of Jean Piaget's genetic epistemology for the analysis of research activity on social project analysis. Although this epistemology is grounded on the construction of general knowledge, I applied it to the cognitive processes of social agents in their research activity. Its main use is a construction and development knowledge field – CDKF – model that is oriented to finding possible paths and equilibration trajectories in system development processes. We put this into practice by following the work of five academic research projects hosted by the LabCOMplex (CEIICH/UNAM) in Mexico. These researchers have been using the Adaptive System – SiAs in Spanish – strategy proposed by the author since 2007. The use of this system features a strong emphasis on second order reflexivity in terms of the cybernetics of cybernetics (von Foerster, 1973 and Scott, 2011) and on heuristic methodology, based on a sociocybernetic perspective (Geyer, 1995, 2005 and Hornung, 2006 a and b).

The heuristic methodology applied to this research is further supplemented with interdisciplinary research activity derived from the Cibercultur@ approach (González, Maass and Amozurrutia, 2007), which gives special attention to system thinking, distributed intelligence and dialogical communication between observed researchers and my own reflections and observations of them. My final goal is to use the CDKF model to represent the dynamics of cognitive processes during research activities.

In the first part, I provide a brief overview of sociocybernetics and Cibercultur@ strategies; I then make use of Piaget's theoretical corpus from which the CDKF model evolved and apply it to social research. In the second part, I summarize the observed researchers' projects, challenges and contexts for dealing with social projects through system thinking. In the third part, I describe CDKF model construction, and end with its application in a case study analysis.

1. Introduction

1.1. The observer and the problem

In the past five years, my attention has been drawn to attentive and thoughtful attitudes towards knowledge developed by social problem observers who carry out their activities through social and systems thinking. This interest stems from a commitment to interdisciplinary research within a segment of Cibercultur@ and my own second order observations, which convinced me of the benefits of applying the sociocybernetic approach to social reflexivity. From this perspective, I've posed several questions about the types of challenges researchers must overcome, as well as sought new forms of concept assimilation and strategies for category integration, both of which are focused on a better understanding of problems and social explanations. My reflections follow von Foerster's and Piaget's systemic thinking, Piaget's and García's epistemological thinking, and Bourdieu's and Moscovicci's social thinking. Von Foerster, Piaget and sometimes García are the main references to the systemic models – SiAs – I`ve constructed and applied in different social analysis projects.

In this chapter, my research focuses on Piaget`s genetic epistemology organized as an analytical research unit within a systemic consolidation into a unit of analysis that operates in a computer program, which I will apply to six case studies. In the analytical research unit, understood as a hierarchical category construction, lies the intuition that as we achieve better forms for constructing and/or developing knowledge, we will gain a better understanding of the key cornerstones of social analysis.

Complementing second order reflexivity, I include two essential components of Piaget's genetic epistemology in the CDKF model: a multi-dialectical process conception in the balancing process of regulations and compensations, and the *alpha, beta and gamma* mechanisms in compensations. These are key to establishing relationships between the three mechanisms and organizing the CDKF model within a system/environment co-evolutionary process.

The cybernetics of cybernetics, that is, systemic thinking within the conception of the research project as a complex system, is at the same time the main activity developed in model construction and its application to social analysis processes. My observation is oriented toward the researchers' reflexivity. As a second order observer, I analyse Piaget`s subject-object interaction mechanisms between the researchers' activity with their object of study, or, more precisely, with the object of construction. The latter is simultaneously another social actor observing more actors. This chain of researcher observations includes reflexivity on subject-object perturbation and the presence of blind spots.

From this point of departure, merging von Foerster's "second order observer" reflexivity with epistemological constructivism's "knowing subject" will allow proposing an *observing subject constructor* for social problem analysis. Although both authors have different conceptions of the "knowledge builder", i.e., von Foerster in terms of an observer of others and of himself, and Piaget in terms of subject-object/subject interactions, they have in common many reflexive attributes that make similar world constructions within a moderate constructivism framework. But what is the background of these observing subjects?

2. Sociocybernetics, Cibercultur@ and genetic epistemology

The epistemological framework of sociocybernetics draws important ideas from Maturana and Varela's biological perspective (1999), Spencer Brown's mathematical perspective (1968), von Glasersfeld's radical constructivism (1990), and von Foerster's neuro-cybernetic perspective (1973, 1984, 1996). Luhmann's social systems theory (1998) integrates these in an encompassing social system theory that is not easy to put into practice but shifts social problem analysis to the same level of complexity as that of physical and natural sciences. The second contribution of sociocybernetics comes from the diverse perspectives of its members, who provide unique viewpoints for understanding knowledge. Such is the case of the "subject-oriented approach and its perverse" by Arne Kjellman (2003), of "cybernetics and the integration of knowledge" by Bernard Scott (2004), of the "unity of science by means of epistemological constructivism" by Bernd Hornung (2006), and of "cybersemiotics" by Soren Brier (2009), among other members of ISA's Research Committee 51.

Key concepts in sociocybernetics focus on von Foerster´s cybernetics of cybernetics, in parallel with a more classical perspective of second order observation of social problems, i.e., a social reflection on social thinking. Von Foerster´s observation identifies blind spots in research activities, connected to an observer's presence in the observed process and a necessary heuristic strategy to approach the object of study, i.e., a non-trivial system conception. This observation is remarkably underscored by systems thinking, especially with regard to the Luhmannian recognition that there can be no system without an environment and no environment without a system. In between, system development reduces the gradient of complexities and co-evolution takes place.

System conception in sociocybernetics is non-trivial: permanent system feedback and feed-forward mechanisms require a heuristic strategy to adapt systems to the environment, and vice versa, in a non-linear path. This non-trivial conception of activities, agents, institutions or social groups crafted as system interactions requires specific models so as to understand their history and present behaviour. The explicit attention to this co-evolution process implies a more integrated and detailed understanding of self-organization, self-catalysis, self-description and system self-production, all of which are essential attributes of the sociocybernetic approach.

Since 2010, members of the LabCOMplex research group have participated in sociocybernetic meetings.[1] We have promoted Piaget's epistemological constructivism and García´s contributions on complex systems in social science.[2] Recently, some of us presented some thoughts on the relationship between sociocybernetics and Cibercultur@ (in Almaguer P., Amozurrutia J.A., González L., Maass M., and Meza M., 2012).

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[1] Almaguer (2010, 2011), Amozurrutia (2004, 2008, 2009,2010), González L. (2010) and González, J.A. and Amozurrutia (2004).

[2] In the inaugural conference of the sociocybernetics meeting in Mexico (2008), Rolando Garcia presented his view on complex systems and the relevance of genetic epistemology as a strong means of understanding and providing better explanations for a complex social systems approach. In the same conference, Margarita Maass presented "La epistemología genética, la interdisciplina y los sistemas complejos de Piaget y García como base para las Comunidades Emergentes de Conocimiento Local" as a paper. José A. Amozurrutia also presented a paper on "Genetic epistemology, basic mathematics and systemic thinking as essential disciplines for social research", and finally Jorge González presented "Cibercultur@, sociocybernetics and complex systems: The growing challenge between 'associationism' and 'constructivism'". These were the first genetic epistemology papers presented in the sociocybernetics field. The main ideas of this chapter were presented as a paper at the 2012 RC51 meeting in Faro, Portugal.

3. Cibercultur@ approach

One of the main ideas of Cibercultur@ is to dedicate special attention to communication processes. Based on what could be called a “togetherness spirit” of group collaboration research, Cibercultur@ seeks to promote a better and more effective dialogical conversation oriented toward the emergence of distributed intelligence. Group intelligence looks for a permanent re-equilibrium of knowledge, derived from an improved availability for listening to the differences and viewpoints of others. Communication derives from a stimulation of interest and the desire to share a problem. This is fostered via permanent connectivity and face-to-face communication, with or without virtual means, and is oriented into consistent meaning and shared sense.

Communication in Cibercultur@ means putting the information together while having in mind an epistemological knowledge and awareness of that same construction. Recursively, these knowledge processes let us creatively rethink and formulate new questions for old problems. Information need not only be organized and integrated in computer systems; it also works with paper and pencil. The main purpose of complexity is to enhance these activities with computer technologies in order to increase and maximize reflexivity for problem analysis. Multi-agent modelling and simulation strategies are key development computer tools. Systems thinking in Cibercultur@ goes hand-in-hand with constructivist epistemology; and the cultivation of these disciplines within a culture of communication yields two results: a theoretical discipline integration[3] by means of interdisciplinary research, and the praxeological approach of these three cultures to social problems. Both goals exist in the framework of a heuristic strategy associated with grounded theory and with the configuration of knowledge-emergent communities.[4]

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[3] This integration condenses three areas of knowledge: communication, information and knowledge, and at the same time is related to a diverse social corpus linked to a wide range of authors like Vygotski, Moscovicci, Bourdieu, Freinet, Freire and many others.

[4] A variety of perspectives within the Cibercultur@ approach have been presented in Amozurrutia (2009), González, L. (2010), González, L. and Maass, M. (2008) and Maass M. (2008, 2009).

4. Genetic epistemology[5]

Piaget is particularly well-known in the educational and psychological fields but at the same time he left us important philosophical contributions. Genetic epistemology is Piaget´s key proposition. His constructivism is not radical: the Piagetian subject constructs reality not in any possible way, far away from reductionisms and relativisms, but by means of constructions of relations between external processes considered as knowable objects or other subjects, and internal processes knowledge constructions done by the subject itself. According to García, knowledge construction or knowledge development is always the result of a dialectical interaction between an external empirical complex in an object or in subjects and an internal knowledge complex in subjects. A very similar approach is found in Luhmann's encounter of complexities between the system and the environment.

Genetic attribution in this context refers to a permanent evolution of structures or system transformations, i.e., temporal organization of processes, within networks of causalities rather than a chain of linear causalities derived from rigid structures. In García's terms, knowledge derives from a dynamic equilibrium between structured phases and structuring knowledge phases.

Piagetian epistemology assumes that objects are constructions of relations which are always a product of a subject's interaction with other subjects and objects. In a broad sense, all actions are integrations and/or differentiations of relations organized in processes. They may be in equilibrium or non-equilibrium states; the equilibration process explains the path from one knowledge level to another. The main purpose of our observing subject *as a constructor* is to identify those processes and how we may understand and explain the changes in them, i.e., how to explain re-equilibrations or de-equilibrations in the research process.[6]

Before presenting the CDKF model in the next section, I will now summarize the empirical complex associated with the challenges and projects of the researcher and the question that led me to reflect upon and try to understand the inherent system thinking and knowledge development characteristics and approaches.

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5 This section is based on Piaget (1961, 1966, 1976, 1977, 1981, 2005) and a more extensive synthesis can be found in Amozurrutia (2011, chapter 4).

6 Although the terms "unbalanced", "rebalanced" and "balanced" are similar to "equilibrium", I prefer the latter because it does not refer to a physical standardization of differences based on the concept of minimum variance, but rather to heterogeneous weighted contributions in system equilibrium.

5. Empirical complex and researchers' challenges

As a first observation of the research process, I will distinguish several relations between different empirical and knowledge domains: There is the *researcher's domain* as an observer aware with his/her limitations. He/she observes direct and explicit components of a social problem and the observation of implicit components in the observables and the blind spots in himself and in his/her research group.

The organization of the *empirical complex*, i.e., actors, actions, environment, derives from the explicit and implicit empirical evidence in the unit of observation. The *knowledge complex* derives from the integration of two or more theoretical corpuses integrated in the unit of analysis. The coupling and inter-definition of the unit of observation with the unit of analysis derive what I refer to as knowledge *construction*, also known as the *object of study*. My target in observing researchers is oriented toward the unit of observation/unit of analysis construction in the CDKF model, from which it will be possible to answer the research questions posed in the researchers' problem analysis.

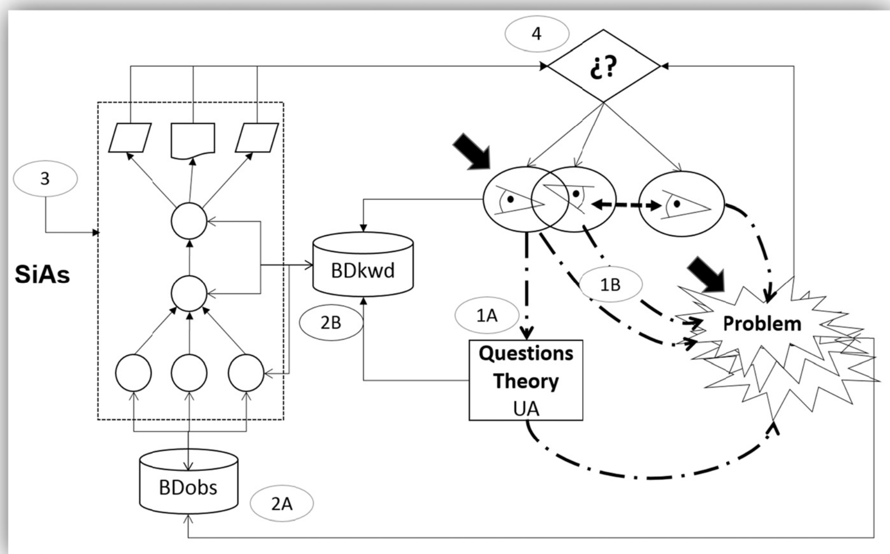
5.1. SiAs approach

The Adaptive System for Social Analysis – SiAs – is not a simple spreadsheet application but rather a modular toolkit based on several types of functions and mathematical expressions associated with a knowledge database and an observables database construction and organization. As modular system software, SiAs is organized as an adaptive structure designed to register observables within variables as nuance functions. The system algorithms – integrating variables and categories, generate diachronic, synchronic graphic representations, sentences explaining variable and category meanings.

SiAs has three main valuation levels, i.e., the observables level; the variable and categorical integration – abstraction functions – level; and the inference or generalization level. This information is organized in a knowledge database. Due to flexible language characteristics and potential ease in dynamically constructing and reconstructing applications, the SiAs spreadsheet version allows the research group to permanently construct and adapt the unit of analysis according to evolutional needs. The SiAs modular structure requires researcher creativity and innovation in order to integrate the theoretical corpus as categories and to construct meanings and discourse explanations related to problem questions and system answers (Amozurrutia, 2011).

Figure 1 shows the main steps in the research dynamic applied to the six case studies. A social problem exists because there are several observers with a similar perspective of the des-equilibration phenomenon (1A and 1B, in figure 1). Main operations are organized in the observables database (DBobs, 2A), relating to independent variables. The construction of the knowledge database (DBkwd, 2B) field relates to the nuances of dependent variables for observables and category criteria for their integration in valuation inferences. A representative SiAs node (3) integrates databases in a complex operation. The conditional symbol in (4) represents the main second order reflection around the completely heuristic strategy. Permanent actualization activities in the knowledge database (2B) and the permanent observables registry (2B) complete the research cycle. Basic research trajectory takes the following route 1A/1B > 2A/2B > 3 > 4 > 2A/2B > 3 > 4 in figure 1. From this methodological perspective, I pose several questions about these trajectories to researchers.

Figure 1. Co-evolution of our observing subject constructor and the empirical complex



Hence the focus is on how researchers assimilate and accommodate new ideas related to system thinking in their own research experience. In the first research stage, I analyse the researcher's knowledge situation before combining the sociocybernetic approach with Cibercultur@'s interdisciplinary research proposition. In the second stage, I analyse research projects developed from bottom-up and top-down dialectical methodologies associated with grounded theory.

Other research initiatives demonstrated availability to participate in a seminar to share relevant methodological and systemic thinking components, although their objects of study, ages, discipline trajectories and university academic levels were quite different. Table 1 summarizes the main characteristics of the researchers' projects.

Table 1. Researchers and projects analysed

Project Identification	Sex and period of research age	Object of study	Study level and main discipline
li	F (22-24)	Health Risk Evaluation	Bach, Sociology
fc	M (52-54)	Music Program Evaluation	MSc, Music
er	F (34-36)	Cultural Political Evaluation	MSc, Culture
em	F (42-47)	Cultural Legislation Evaluation	MSc, Culture
mc	M (38-39)	Researchers Capitals Analysis	PhD,Communication

5.2. The research projects and questions

The main questions in the selected projects were:

- How to explain the behaviour of the population of Mexico City, the media, and the authorities regarding the influenza pandemic of 2010 (li);
- How to evaluate a new proposal for a higher education musical programme (fc);
- How to build cultural policy criteria for university evaluation (er);
- How to propose new cultural legislation for the state of Nayarit (em);
- How to evaluate the science policy promoted by the responsible national official institution from the perspective of the field of the power derived from Bourdieu's capitals (mc).

As we can see in table 1, the researchers' ages are quite different; researchers over 35 years had different system assimilation capacities than researchers under 25, who showed better qualifications.

As stated, questions to the researchers were asked during two stages of the research process. The first group of questions intended to register initial conditions and researchers' expectations with regard to system thinking within a computer system. Questions were oriented toward: q1) the central play of the unit of analysis; q2) the different possibilities of interest in graphical and text system representations; and q3) the researchers' predisposition for participating in dialogical reflection with the tutor and other researchers in an academic seminar context.

The second group of questions was specific to system thinking and interaction with the SiAs system concepts strategy, and the expected results. Question (q4) considers how researchers confronted the process of transforming data into observables, (q5) deals with how researchers remember the process construction in the first approximation of the unit of analysis, (q6) deals with how researchers remember their conception of interphase, differentiation and integration system functions, evaluation factors, observables and knowledge database and (q7) deals with how researchers experience the system adaptation capacity with regard to their discussions with other researchers.

Each of these questions required several cognitive operations in order to understand what system thinking applied to a social problem means, and, consequently, how researchers epistemologically approach the sociocybernetic research process with regard to the analysis of social problems. To get some insight into these questions and processes, the next section presents the epistemic frame, i.e., the axiological criteria, for analysing and explaining trajectories and operations based on a different spatial representation of knowledge regarding the six projects in table 1.

6. CDKF model integration

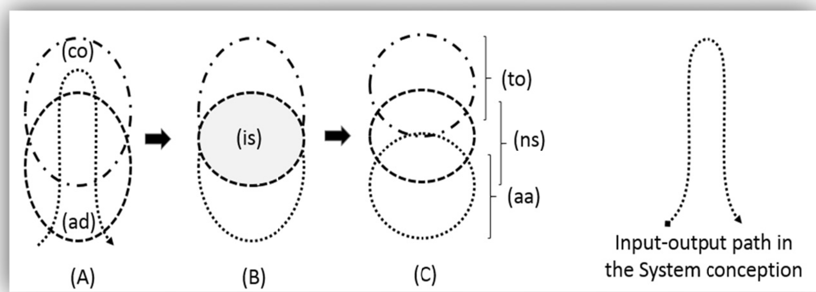
In this section, I will show the components and relations in the knowledge field in three steps. The first take on a *macro* perspective, that is, Piaget's general knowledge conception. Next, I complement those components and relations with a *meso* perspective, which is the most familiar conceptualization of Piaget's concepts. Finally, I present the main basic and *micro* operations that take place inside *meso* and *macro* functions and subsystems.

6.1. A *macro* perspective for CDKF

The construction of a knowledge field from Piaget's epistemological theory begins from a *macro*-organized perspective and arrives at *meso* and *micro* perspectives. My departure point is the intersection of two main partitions or subdivisions derived from broad Piagetian concepts: the vertical partition comes from the interaction between an adaptive component and an organizational component; the horizontal partition comes from the interaction between the internalization and exteriorization components.

Figure 2 details these components from a systemic perspective: the horizontal partition or first knowledge stratum division is equivalent to an adaptation input and output subsystem (ad) and a cognitive organization subsystem (co). It is important to highlight the relevance of an interphase between those subsystems, (is), in figure 2B. From this zone emerges a new subsystem, which expands the input/output operations in the adaptive stratum and takes part in the knowledge organization subsystem (see figure 2C).

Figure 2. Vertical partitions in Piaget's knowledge theory

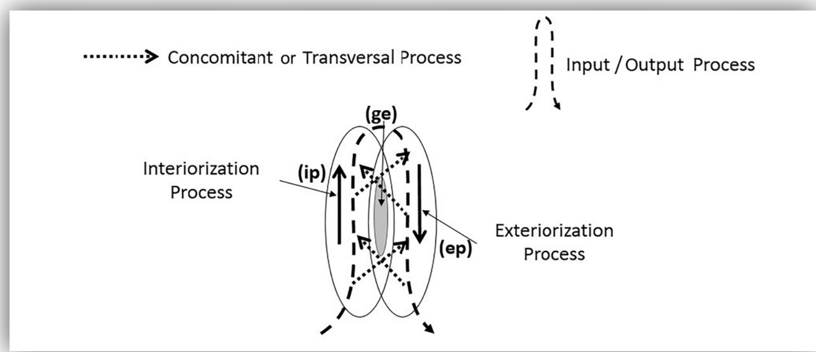


From these horizontal subdivisions, Piaget defines three main mechanisms operating in those subsystems. Beginning with the general input/output subsystem (aa), identified as the *alpha* behaviour in equilibration knowledge activities in figure 2C, we see a coupling with a network of middle subsystems (ns), identified as the *beta* behaviour in equilibration knowledge activities, and finally the global integration of subsystems into a relative totality system, (to), identified as the *gamma* behaviour in equilibration knowledge activities, is achieved.[7]

[7] These three levels of knowledge development are identified by Rolando García as the *intra, inter*, and *trans*-objectual mechanisms in scientific knowledge construction (García, 1982).

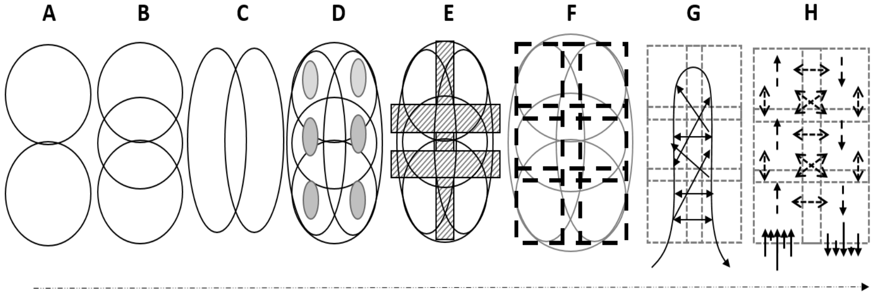
The vertical partition, or second knowledge stratum division, is equivalent to the general internalizing or input assimilation process (ip) shown in figure 3, along with an exteriorization or output general accommodation process (ep). Again, an intersection between these general processes will generate a general equilibrium interphase (ge).

Figure 3. Horizontal partition in Piaget's knowledge theory



In figure 4, we see a general integration process for the CDKF derived from Piaget's equilibrium theory. In that figure, 4D represents the integration of partitions from which emerge six main discursive function zones (Piaget, 2008). In 4E, the three rectangles refer to the three main dialectical equilibrium zones between horizontal and vertical strata, and in 4F the first delimitation of CDK zones is shown. Finally, in 4G, I include the main flow of information and the main forces of communication – not just those derived from the input/output path but also from transversal and concomitant paths in the knowledge field space and the main differentiation of forces in the CDK field, in 4H.

Figure 4. Vertical and horizontal partitions in Piaget's knowledge theory and the identification of the knowledge field (F to G)



Although basic relations may be considered as micro components, they can be introduced to complement a perspective of macro processes. Piaget distinguishes three types of basic relations: empirical, of implication, and logical; which are connected in a network of interrelations associated with different integration and differentiation micro and macro operations. There is no clear division between types of relations in the chain construction process. From these types of relations, it is possible to construct chains of exogenous-endogenous bridges between physical, biological and physiological brain domains. Through them, it is possible to explain knowledge construction from different levels of observation; other types of relations are causal relations and interdependences, which will be defined later.

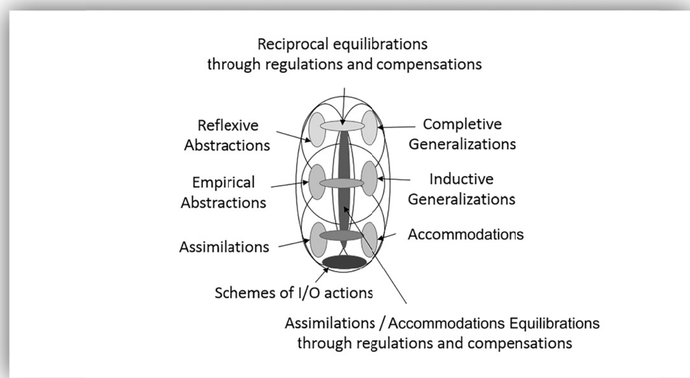
Empirical relations define couplings between outer materialities with skin cells, immersed with dendrites and groups of neurons associated to our five senses; they are exogenous-endogenous neuron bridges. For Piaget, outer materialities are not only physical elements but also other subjects with proper relational constructions. "Action schemes" organize and integrate empirical relations in subsystems. Subsequently, these subsystems integrate through conditional phase operations, and several action schemes joined by means of "relations of implication". This network of integrations operates as endogenous neural centres and configures new subsystems of neuronal organizations oriented to construct new meanings. Operations like distinctions, sequencing and ordering explain this level of subsystem organization.

6.2. A *meso* perspective for CDKF

On a meso level of organization, subsystem structures are in permanent "assimilation and accommodation" processes, and they operate on classifications and basic set correspondences between subsystems. On a deeper level of construction, i.e., a higher brain level, relations of implication are integrated into new subsystems. The operations are again incorporated and combined in new forms and conditions organized for new meanings and purposes; they are "logical and mathematical relations". Each integration process results in a new signification level, as concepts, categories and symbols, and new equilibrium conditions are established.

This *meso* level contains the classical organization criteria of the main general functions in Piaget´s knowledge construction. Figure 5 shows these functions, together with the main equilibration zones between them.

Figure 5. Main knowledge general functions in the CDKF



What follows is a practical definition of activities as capacities associated with the analysis of research activities:

Assimilations: the capacity to be able to hear and understand new ideas and practices. It is concomitant with accommodation functions.

Accommodations: the capacity and the ability to implement practical ideas in new and/or already known languages. It is concomitant with assimilation functions.

Empirical abstractions: the capacity to understand and integrate properties of empirical observables with new or old ideas. It is concomitant with inductive generalization functions.

Inductive generalizations: the capacity and the ability to differentiate empirical realities and to put in practice new ideas and explain them in new and/or already known languages. It is concomitant with empirical abstraction functions.

Reflexive abstractions: the capacity to understand empirical abstraction ideas and integrate them into new concepts. It is concomitant with completive generalization functions.

Completive generalizations: the capacity and ability to differentiate types of logical comprehension and integrate them in new and/or already known languages. It is concomitant with reflexive abstraction functions.

Regulations: the capacity to create a correction mechanism for maintaining a steady control of processes. They are mostly related to homeostatic behaviour.

Compensations: the capacity to create a correction mechanism for rectifying control in processes. They are mostly related to changes in homeostatic behaviour.

Reciprocal equilibrations through regulations and compensations: the capacity and ability to conjugate affirmations and negations, integrations and differentiations in various organization behaviours i.e., alpha beta and gamma, through a dialectical process.

Assimilation/accommodation equilibrations through regulations and compensations: the capacity and ability to conjugate concomitant relations between internalization and exteriorization processes through a dialectical process.

There is a "movement" from these *meso* operations, general integration processes between adaptation (ad) and organization subsystems (co); see figure 2. It goes from empirical relations in assimilations/accommodations to implication relations and logical relations. This construction implies different subsystem levels of organization through abstraction/generalization operations.

This meso description of knowledge construction is, at the same time, a concomitant interaction between the *understanding knowledge component,* associated with an *internalization general process (ip* in figure 3*), in correspondence with* a second knowledge component oriented to an *exteriorization* general process *(ep* in figure 3) and devoted to different *language constructions*.

The general internalization and integration process **moves** from empirical relations to implication relations and logical relations into different subsystem levels and organization through abstraction operations. This operation is subdivided by Piaget into two phases: one of *empirical abstractions* related to the knowledge process associated with empirical evidence perceived by our senses, and a second with *reflexive abstraction processes* which relate to more elaborate and symbolic knowledge operations.

At this point, logical relations relate to implication relations, which flow in different neural paths through new empirical relations centres associated with the muscles. This chain of operations are *generalization processes* which in correspondence with abstraction processes enable language construction associated with the way the subject reacts or interacts with others. The first stage of generalization is a *completive* type associated with logical relations and the decision process, while the second generalization stage relates to implication relations and empirical relations. It is an *inductive generalization process* related to the accommodation process and relates to the mood of the subject's responses in his/her interaction with others.

This chain of relations is organized in terms of operations and processes within dynamic structures, which may or may not be in equilibrium. This depends on the subject's attributes and on the way he/she responds to environmental conditioning; non-equilibrium conditions derive from the desires or needs generated inside the subject. In both cases, re-equilibrium emerges by the necessity to re-establish a non-critical disequilibrium but to operate in a dynamic shareable equilibrium.

Epistemological operations of *regulations* maintain the levels of a dynamic equilibrium in a homeostatic stage by means of feedback mechanisms; when this stage of equilibrium is not enough to solve permanent irritations or perturbations, *compensations* enter into play. These operations are *macro* processes operating over *meso* processes. Interactions between abstractions, generalizations, regulations and compensations orient and modify the homeostatic mechanisms and find new equilibrium conditions by means of feedforward mechanisms. Compensations are operations that modify regulation conditions in subsystem characteristics in order to modify established limits and propose new directions for re-equilibration processes. They operate in terms of *positive and negative compensations*. Piaget even proposes the possibility of *maximizing the equilibration process* developed by the subject in its interaction with his/her environment with other objects and subjects.[8]

[8] In Piaget (1978), we find a deep analysis of the epigenetic processes that show how traditional perturbations from the environment to gen level can be reverted. Using an epistemological language with biological conceptualizations, the author

The above descriptions show us three different levels, all of which interconnect in a complex network with different neural centres and with proper integration and differentiation functions oriented toward the perception, reflexivity and inference processes. The first level, i.e., the one associated with physical behaviour, operates with empirical relations associated with action schemes with assimilation and accommodation processes. Basic regulation and compensation operations are present. Piaget refers to this level as an a*lpha* level integrated by sensory-motor subsystems. A second *beta* level operates mainly with implication relations associated with empirical abstractions and inductive generalizations processes; again, a *beta* level with subsystem operations associated with emotional and rational behaviours. The third level, the g*amma* level, is associated with rational behaviour and operates by means of logical and mathematical types of relations associated with reflexive abstractions and completive generalization processes.

The continuity of these processes allowed Piaget to derive coherent inferences to explain "knowledge construction" from the first months of life to the first 15 years of experiences. After the construction of this stage, he claims, humans develop knowledge.

The great correspondences between Piaget's epistemological and system thinking in sociocybernetics must be highlighted. In both cases, system self-organization is oriented toward the coordination of input-output operations related to system process organizations and objectives. Those processes are equivalent to assimilation-accommodation operations merged with integrations and differentiations oriented toward concept and symbol constructions in correspondence with explanation processes. Both systems conduct and regulate system operations by means of feedback/regulation, and feed-forward/compensation mechanisms; both perspectives are equivalent to the main operations in first and second order cybernetics and correspond to the main operations in Piaget's equilibration theory.

6.3. A *micro* perspective for CDKF

In CDKS, the *micro* level perspective refers to the group of Piagetian elementary operations that precisely describe the mechanisms in the previously mentioned *meso* functions. As explained, their point of departure is action, and actions are constructed with three types of basic

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explains how transformation processes take place from the gen to physiological levels.

relations, a special case of interdependences. They are a complex group of logical and implication relations that establish a dynamic correspondence between two entities or neural conglomerates while seeking dynamic equilibration. The correspondences are interwoven in regulation and compensation alpha, beta, and gamma behaviour mechanisms that are oriented toward the coordination of relations, mutual enrichment between entities and conservation of total dynamic equilibrium.

On this micro level, the main operations are built from *assertions* as statements and *distinctions* as negations. Considering these elementary operations, Piaget derives order, seriations and classifications, and with these, subsequent operations like combinations and permutations are made possible. As previously mentioned, all these basic and elementary operations – and functions – explain *meso* and *macro* processes in terms of empirical, implication and logical or mathematical relations. The main challenge in the model I now propose is to relate all three levels in a group of mechanisms integrated in a unit of analysis that lets us evaluate and assess knowledge construction processes.

6.4. CDKF zones and unit of analysis correspondences

Our next step is to define the field of zones and forces of knowledge. Researchers' activities will now be represented and evaluated. In figure 6, I present the main zones and paths and their relationship with the SiAs basic scheme for units of analysis.